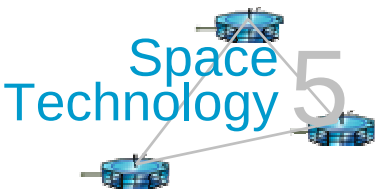


Space Technology 5 MISSION

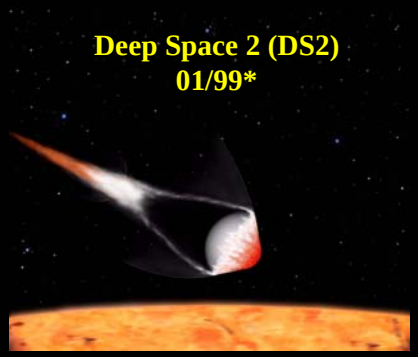
SECAS MEETING

July 23, 2001

J.A. Slavin
ST 5 Project Scientist

New Millennium Program Overview

Deep Space 1 (DS1)
10/98*

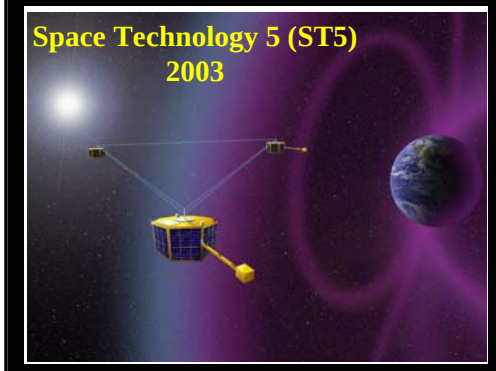


Deep Space 2 (DS2)
01/99*

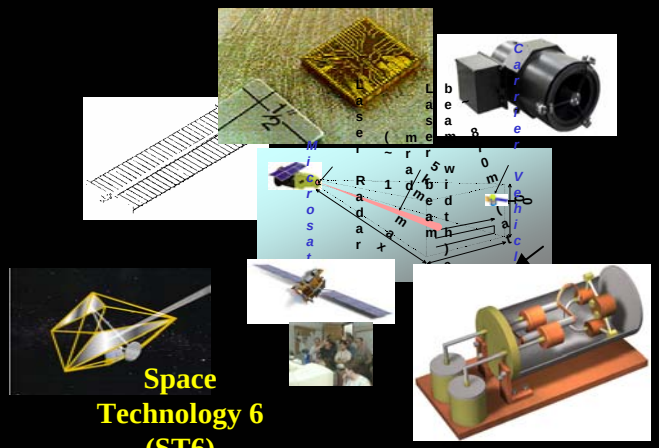
Earth Orbiting 1 (EO1)
11/00*

Earth Observing 3 (EO3)
2004

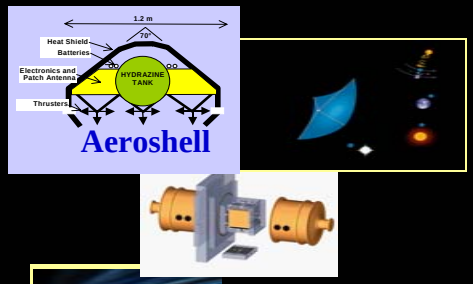
A cross-Enterprise program to identify and flight validate breakthrough technologies that will significantly benefit future Space Science and Earth Science missions.



Space Technology 5 (ST5)
2003



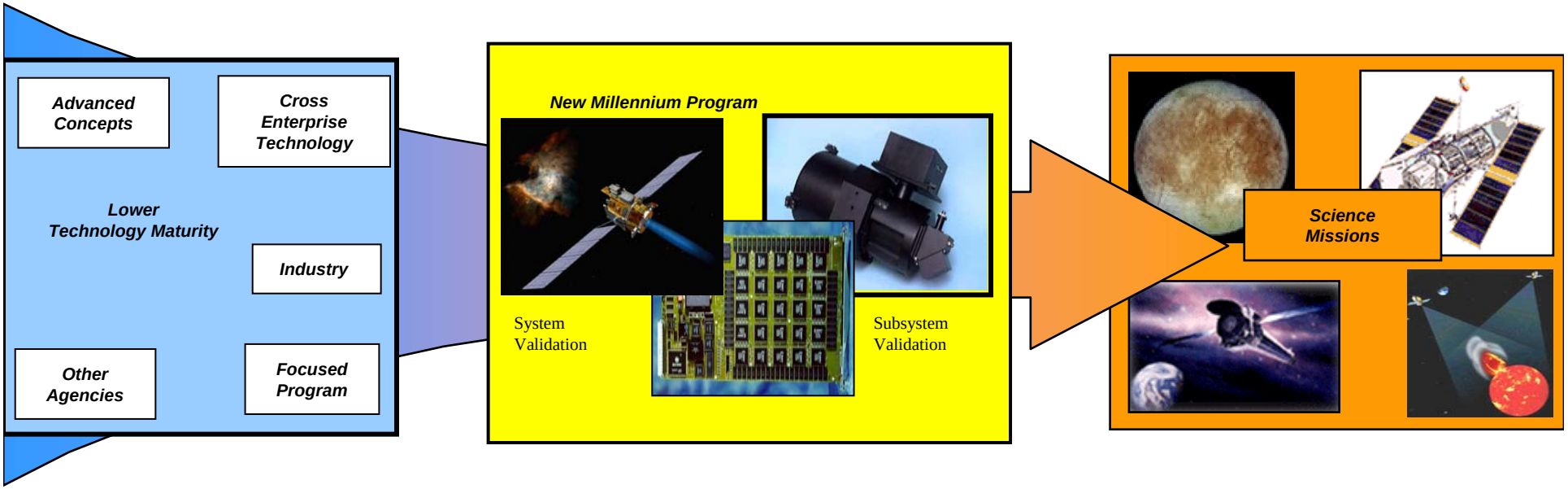
Space
Technology 6
(ST6)
2003-2004

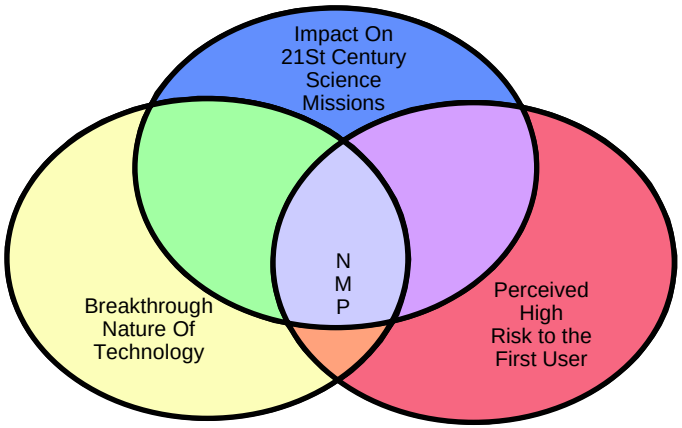


Space Technology 7
(ST7)
2004-2005

* Actual Launch Date

Flight Validation of Breakthrough Technologies to Benefit Future Space and Earth Science Missions





Breakthrough technologies

- Enable new capabilities to meet Earth and Space Science needs
- Reduce costs of future missions

Flight validation

- Mitigates risks to first users
- Enables rapid technology infusion into future missions

ST 5 Project Concept

Space Technology 5

Miniature Spacecraft

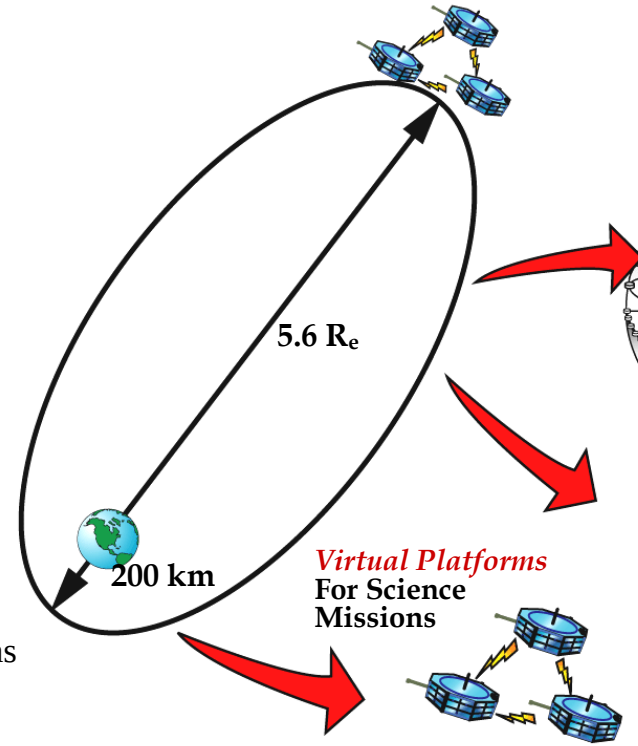
- Systems Design Integration and Test Technologies

Candidate Spacecraft Technologies

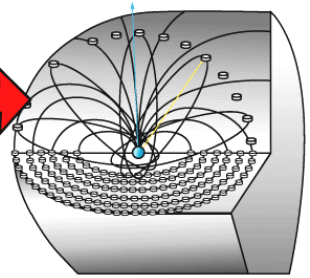
- 5V bus - 1/4V logic
- Li-Ion batteries
- Miniature transponder
- Miniature Thrusters
- Multi-functional structure
- Variable emittance coatings

Constellation Control, Coordination, and Operations Architecture

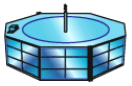
- Ground system autonomy
- Relative ranging
- Intra-constellation communications



Constellation Class Missions
Simultaneous, Multipoint, In-Situ Characterization of the Magnetosphere



Single Nanosats and Probes
Reduced Risk Small Spacecraft Bus for Low Cost Missions

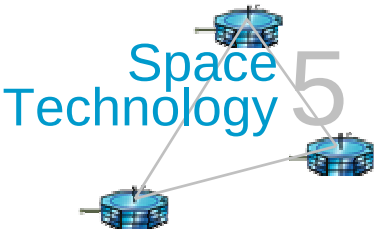


Virtual Platforms
For Science Missions

TECHNOLOGY **VALIDATION** **INFUSION**

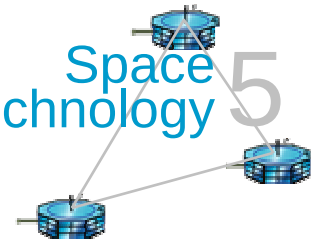
J.A. Slavin
ST 5 Project Scientist

Chronological History of ST-5



Jul '99:	***GSFC ST-5 Proposal submitted***
Aug '99:	***GSFC Proposal accepted***
May '00:	***Systems Concept Review***
Feb '01:	***Science Validation MAG selected***
June '01:	***Preliminary Design Review***
August '01?:	***NMP Confirmation Assessment***
September '01?:	***HQ Confirmation Review***

ST-5 Mission Goals

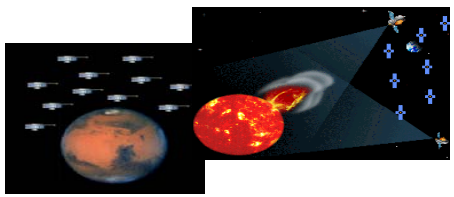


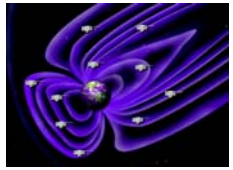
The ST-5 mission has the following level-one mission requirements:

1. ***Design, develop, integrate, and operate a full service 20-kg class spacecraft through the use of NMP assigned technologies;***
2. ***Demonstrate the ability to support accurate, research quality scientific measurements using this class of spacecraft;***
3. ***Design, develop, and operate multiple spacecraft to act as a single constellation rather than as individual elements.***

SEC Roadmap Constellation Missions

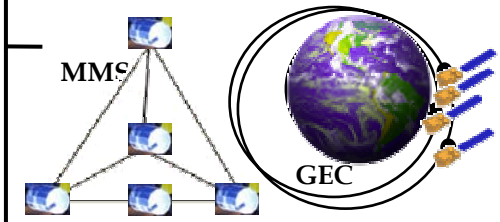
Space Technology 5





Mid-term Missions:
- Magnetospheric Constellation
- Inner Magnetospheric Constellation
- Dayside Boundary Constellation
- Global ITM Constellation

Far-term Missions:
- Solar Flotilla
- Inner Heliospheric Constellation
- Outer Heliospheric Radio Imager
- Planetary Constellations



Near-term Missions:
- Magnetospheric Multiscale
- Geospace Electrodynamic Connections

Cost ($M): 1, 10, 100

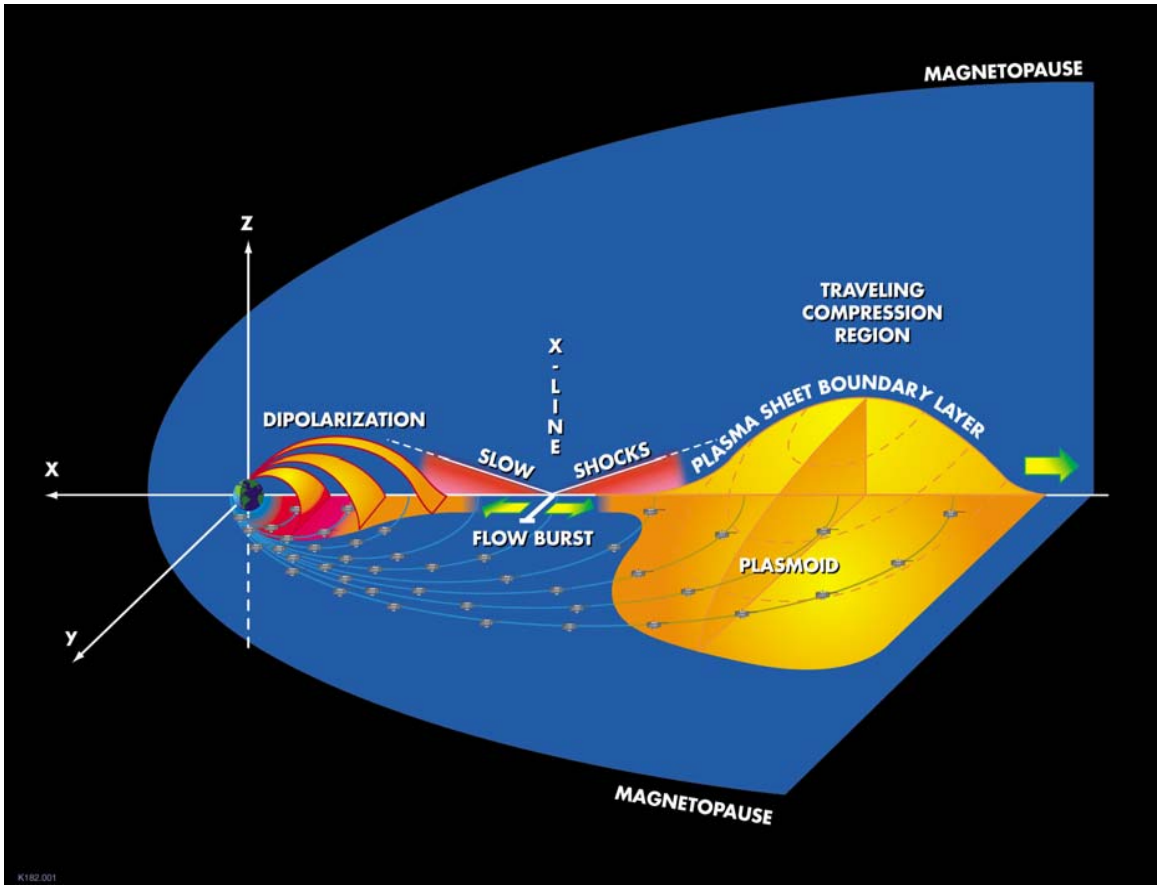
Number of spacecraft: 100, 10, 1

Mass (kg): 10, 100, 1000

5, 10, 15 Years

J.A. Slavin
ST 5 Project Scientist

Space Technology 5



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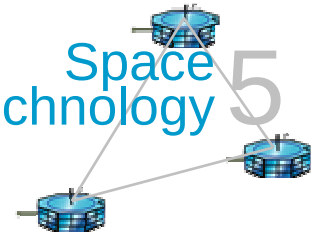
Technology Infusion Into Roadmap Missions

Space Technology 5



SEC
Enable multipoint observations separating space and time measurement of dynamic phenomena in the Sun-Earth Environment

SSE
Enable multipoint observations separating space and time measurement of dynamic phenomena in magnetospheres and atmospheres of inner and outer planets

Earth Science
Enable multiplatform coordinated observations, reductions in satellite size, mass and cost, virtual platforms with distributed instrumentation

Commercial and General Space Industry

Validation of technology enabling intelligent constellations of smart spacecraft

Technologies

- Magnetometer
- Energetic Particle Detector
- Variable-E Coatings
- 15 cm X-Band Antenna
- 250 Gram Sun Sensor
- 500 Gram X-Band Transponder
- Multifunction Structure
- Miniature Deployment Actuator
- Triple Junction Solar Cells
- CCNT
- Low-Voltage Bus (5V)
- Micro Thruster
- Li-Ion Battery
- ¼ V Logic (Culprit)
- Autonomous Constellation Mgmt S/W

Mag Constellation
Simultaneous in-situ observations of the Earth;s magnetic tail
~100 nanospacecraft

Dayside Boundary Constellation
Energy transfer in magnetosphere
~39 nanospacecraft

Explorers
Support lower cost future mission by reduction in spacecraft mass/power increased constellation size without increase in cost for missions like Grand Tour Cluster

Solar Flotilla
In-situ solar system wide space weather
12 nanospacecraft

Inner Mag Constellation
Radiation belt dynamics
~42 nanospacecraft

Global ITM Constellation
Upper atmosphere space weather
24 nanospacecraft

Other Potential Constellation Missions
- Inner Heliospheric Constellation
- Heliospheric Radio Imager

Mars
Supports future missions establishing permannent presence, coordination of multiplatform observations (aerobot, airplane, surface, micromissions, and orbit)]

Pluto-Kuiper Express
Demonstrates onboard autonomy and spacecraft miniaturization in concert with X2000 program objectives

Discovery
Supports future inner planet missions such as JANUS

Other Outer Planetary Missions
Demonstrates onboard autonomy and spacecraft miniaturization in concert with X2000 program objectives

EOS-9
Global precipitation monitoring 8 nanosatellites in formation with core spacecraft

OP-3
Temperature and moisture sounding 8 or more spacecraft

EX-2 Enhanced Science Follow-on
Time varying radiative flux
8 or more spacecraft

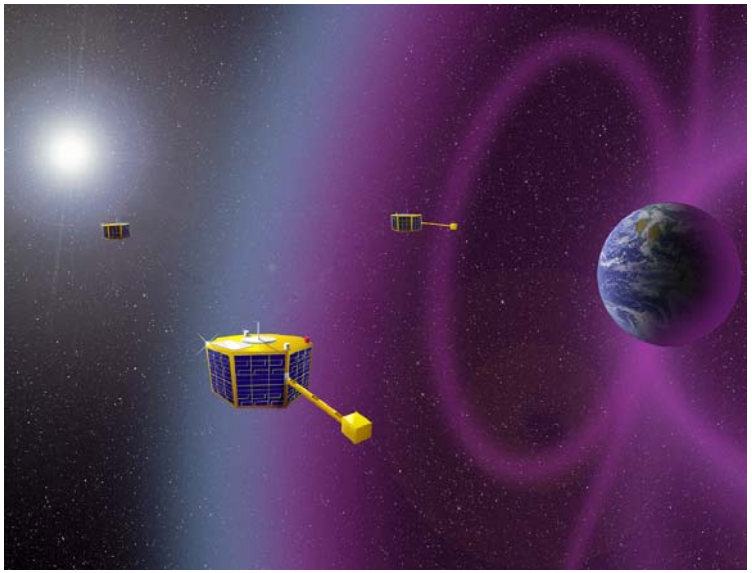
ESSP
Supports lower cost future missions by reduction in spacecraft mass/power opens up new avenues for research through increased temporal resolution and coordinated observations/virtual platforms

Technologies would be generally available for use on future NASA science missions as well as for commercial and other space ventures. Small satellite buses and components could be made available through future RSDO procurements.

ST5 TECHNOLOGIES

Li-ion battery

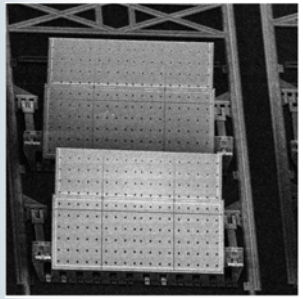
Constellation Communications & Navigation Transceiver



Autonomous ground ops

CULPRIT R-S Encoder & Signal Conv.

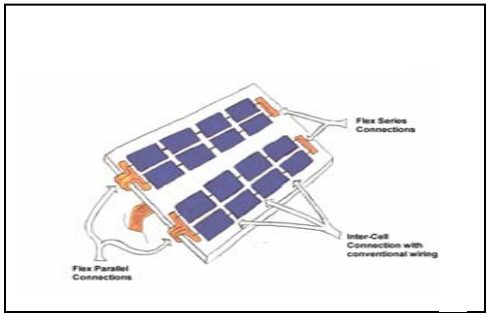
Ultra-low power electronics



Variable e surfaces

X-band transponder

Micro-thruster



Multi-functional structure

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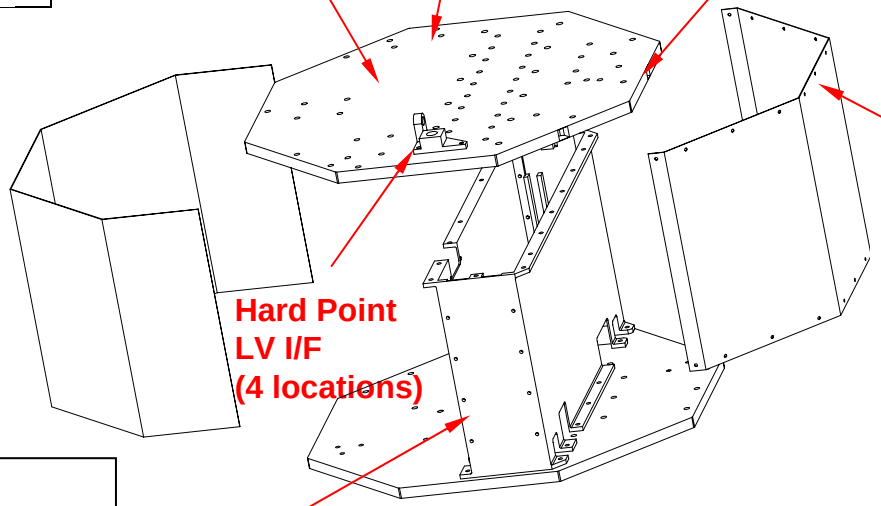
ST 5 Project Scientist

ST5 – IMPLICIT TECHNOLOGIES

Space Technology 5

Miniature actuators

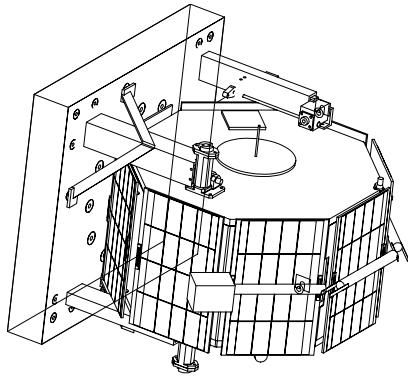
Miniature magnetometer



Low-voltage bus

Miniature passive nutation damper

Miniature sun sensor



Deployer mechanism

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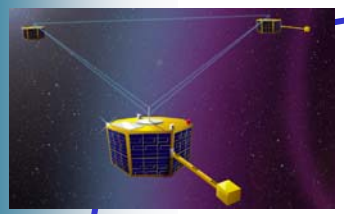
System Verification/Validation Overview

Space Technology 5



Micro-Satellite Design and Build

"Design, development, integration, test and operation of a full service 20 kg class spacecraft through the use of multiple new technologies"

- Full Functional Spacecraft
  - Spacecraft Mass Properties
  - Appendage Deployments
  - Pointing Performance
- Radiometric Performance
  - X-Band Technology
- Secondary Payload Launch
  - Volume Limitations
  - Separation System
- Radiation Environment

Research-Quality Spacecraft

"The ability to achieve accurate research-quality scientific measurements using a 20 kg-class spacecraft"

- Time Knowledge
- Platform for In-situ Measurements
  - Vehicle Magnetic Sig
  - Support "Science Grade" Magnetometer
- Autonomous Cooperative Data Collection (Science Event Warning)

Constellation Mission

"The design, development, and operation of multiple spacecraft to act as a single constellation rather than as individual elements"

- Constellation Mission
  - Coordinating Mission Geometry
  - Processing of Data Streams from Multiple Spacecraft
- Inter-Spacecraft Communication
  - CCNT Technology
- Autonomous Constellation Management
  - SatTrack Technology
- "Lights Out" Ops

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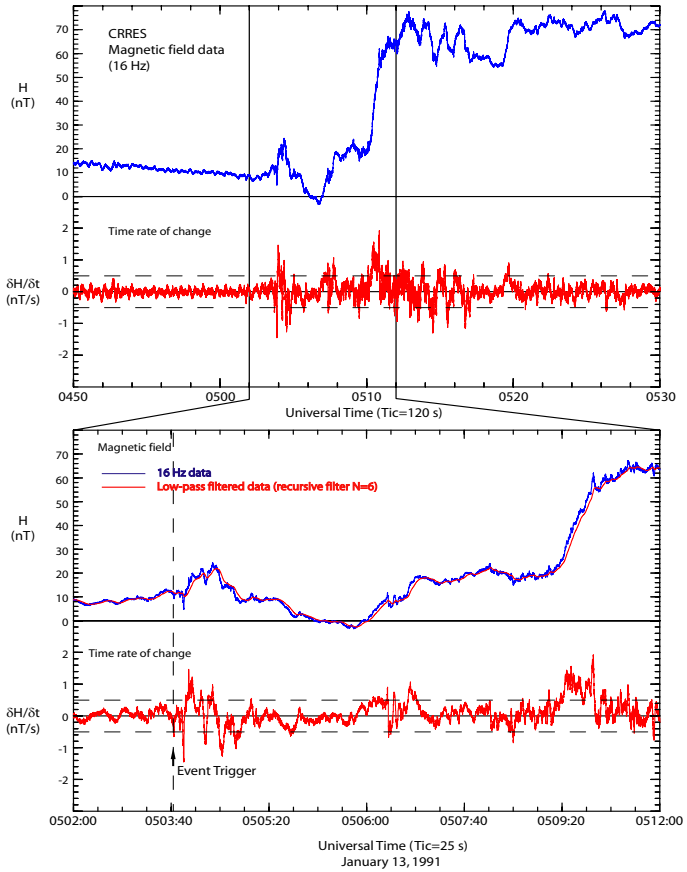
ST 5 Project Scientist

Science Validation

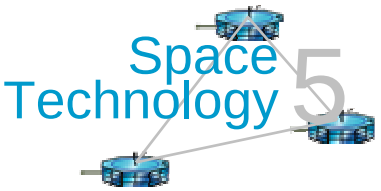
Space Technology 5

Flight validate:

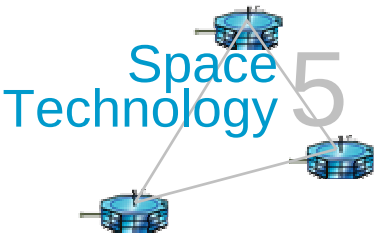
- **Miniaturized, research-grade vector magnetometer**
- **ST-5 capability to act as a platform for taking in situ magnetic field measurements**
- **Autonomous operations and response to science events**
- **Constellation-level cooperative data collection during science events**



ST 5 Project Concerns



- Cost Growth ($29M to $47M) due to:
  - Overly optimistic new technology TRLs and costing;
  - New technology co-funding short-falls;
  - NIAT costs;
  - Center mandated risk reduction;
  - Schedule delays and unanticipated costs associated with launch.
- Duration and complexity of secondary ride process



ST-5 Benefits to NASA

- ***Pathfinder for all missions requiring highly capable, small spacecraft - whether strategic (e.g., MagCon) and selected for development through the Explorer, Discovery and Earth Probes Programs;***
- ***Pathfinder for constellation mission operations, autonomy, inter-s/c ranging, communications and manufacturability/costing/schedule/ reliability;***
- ***Flight validation vehicle for miniaturized subsystems (e.g., sun sensor, X-Band transponder, CCNT, magnetometer, etc.);***
- ***Pathfinder for secondary launches as a means of reducing cost for near-earth scientific spacecraft (e.g., LWS Geospace Element).***